Title: METHOD FOR MEASURING AND
COMPENSATING SKEWS OF DATA
TRANSMISSION LINE
Applicant: Paul Georg Lindt
Serial No.: 10/808,145
Atty Docket: 1406/142/2

DRAM0

DRAM1

DRAM2

DRAM3

DRAM4

HUB

DRAM5

DRAM6

DRAM7

DRAM8

FIG. 1

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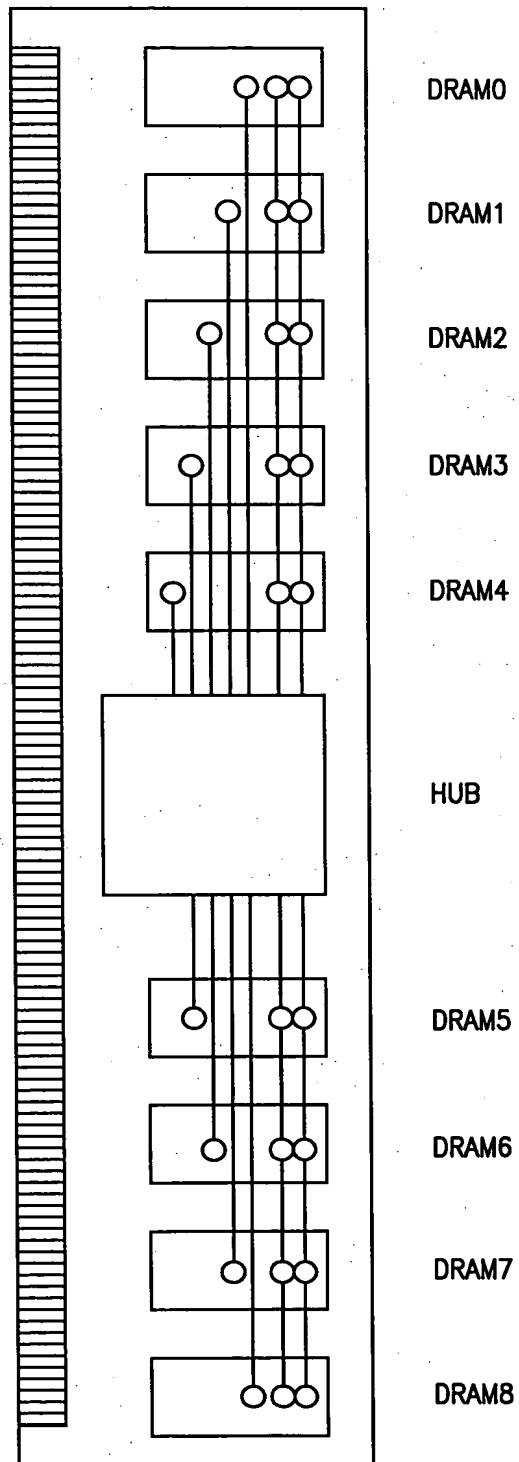Atty Docket: 1406/142/2

FIG. 2

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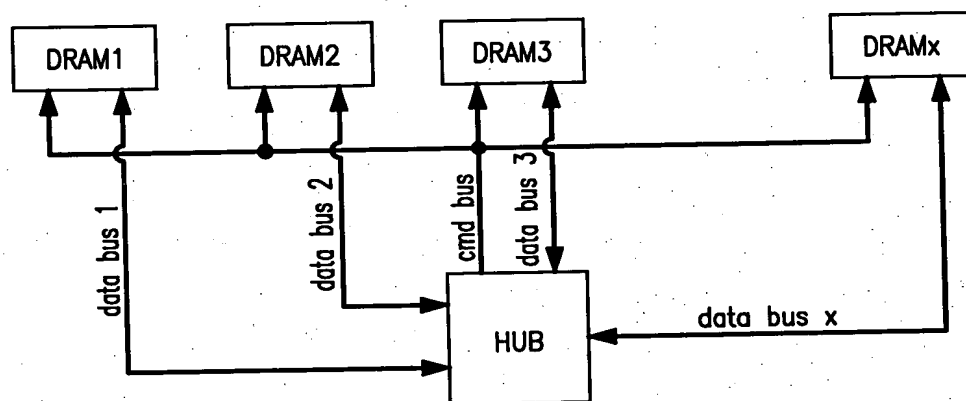
FIG. 3

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Data complete

Data transmitter

Data transmitter 2

Data transmitter 1

1UI=bit duration
(minimum cycle duration)

Danger to data integrity resulting from delay time differences

# FIG. 4

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FIG. 5

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FIG. 6

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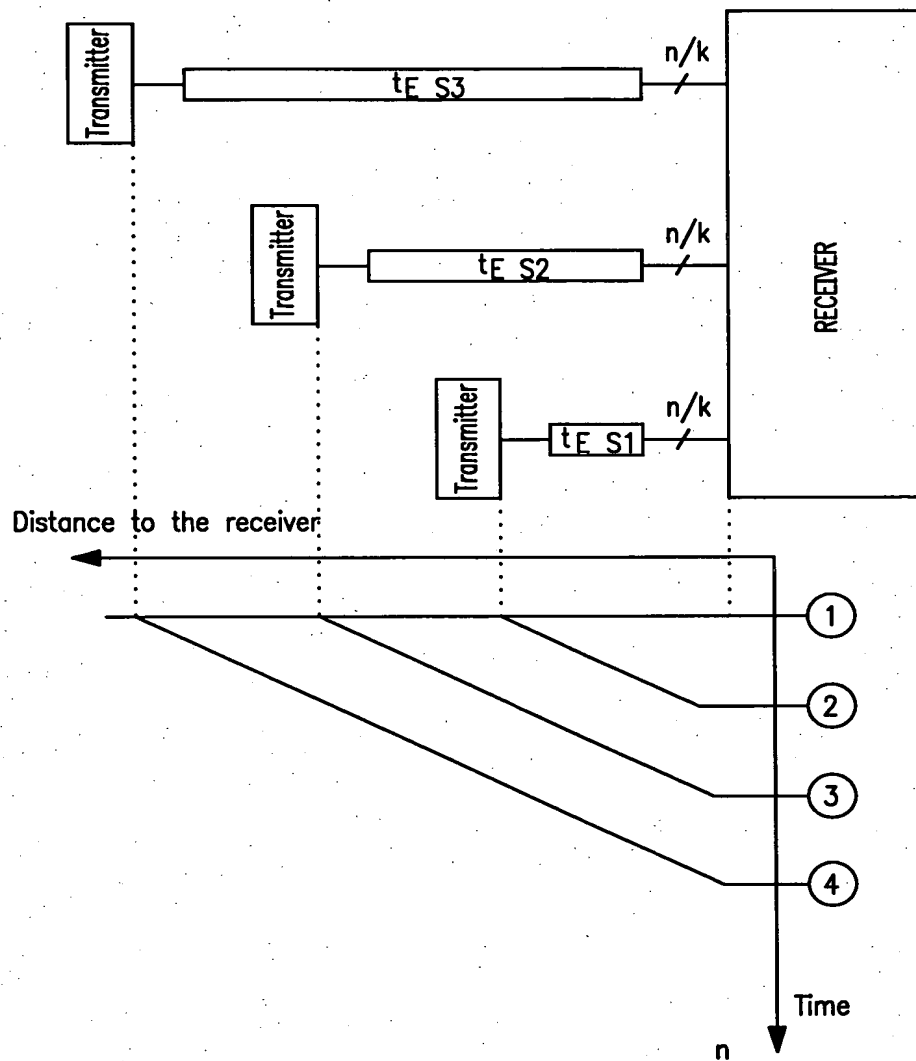Serial No.: 10/808,145
Atty Docket: 1406/142/2

Start — S0

HUB power up — S1

send cmd up
DRAMs to start
transmission of
MV with i=0 — S2

measure skew on
data bus — S3

compensate skew — S4

ready for data
transmission — S5

Stop — S6

FIG. 7

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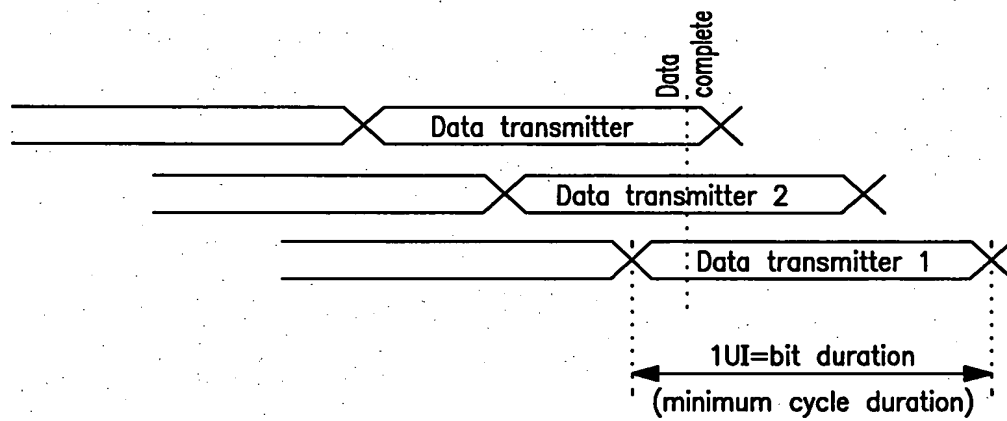Serial No.: 10/808,145
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Skew  Measurement  Procedure  (S3)

Start skew measurement — S30-0

S3-1 — enable clock and data recovery

variables
$i=0$, skew=0, insert=0

cdr ocked

S3-2 — compare RV with MV

RV=Reference Vector
MV=Measurement Vector

S3-3 — match

no

yes

S3-4 — insert=insert+$2^i$    tracks the number of inserted UIs

S3-5 — delay lane by $2^i$ UI   delays data line by $2^i$ UIs

S3-6 — $i=i+1$    changes RV

S3-7 — send cmd(i)    changes MV

S3-8 — $i=i+1$

S3-9 — send cmd(i)

S3-10 — compare RV with MV

S3-11 — match

no    yes

S3-12 — skew=$2^i$-insert

S3-13 — skew= -insert

S3-14 — remove inserted delays

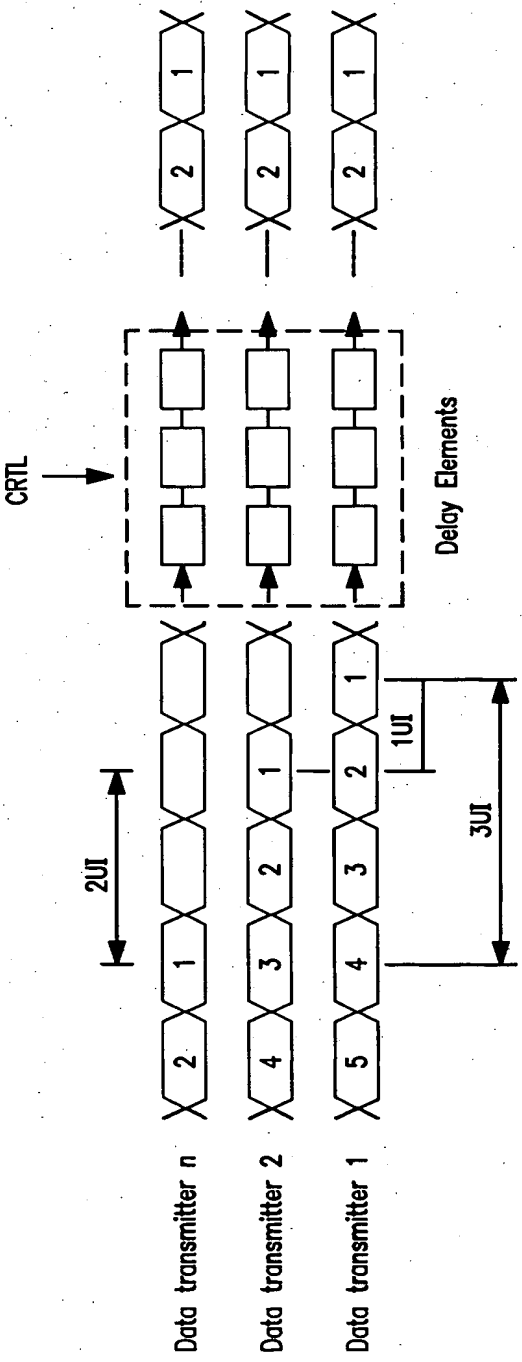S3-15 — skew measurement complete

Stop

FIG. 8

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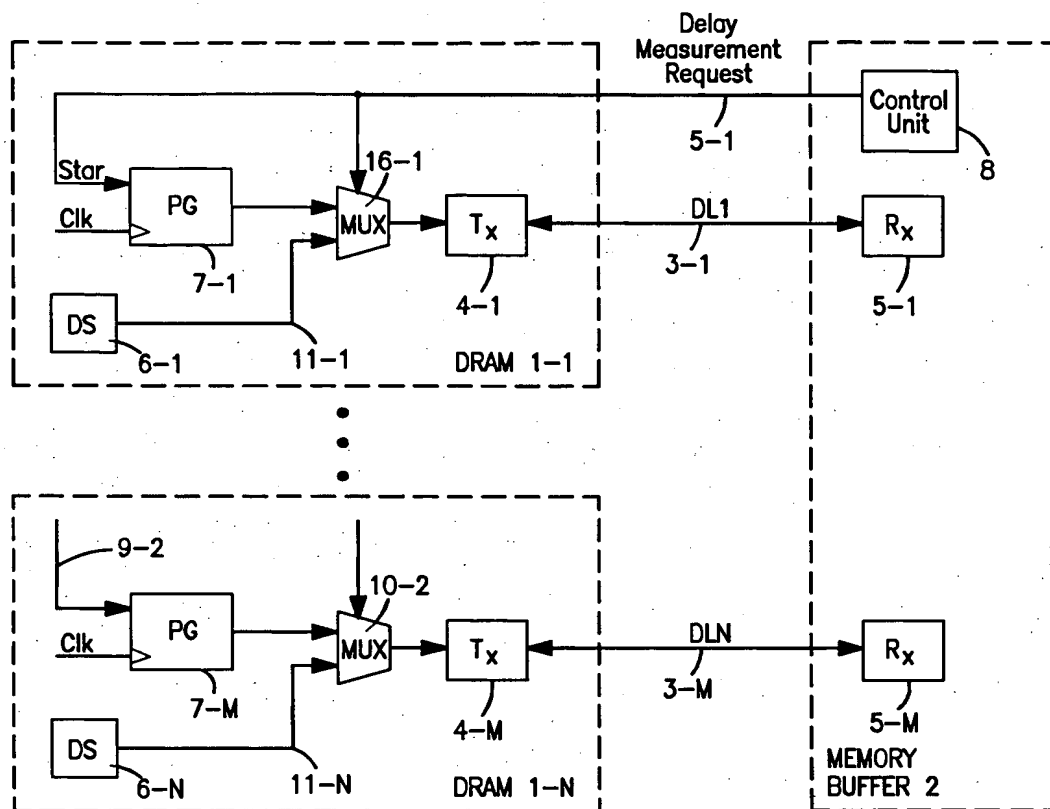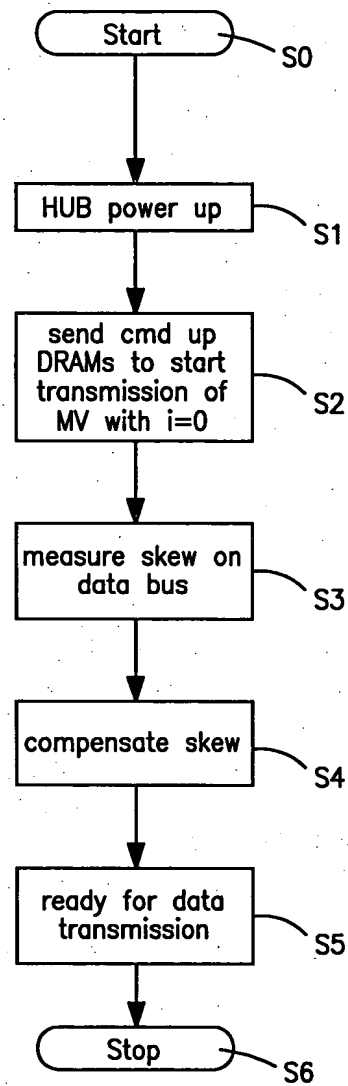Serial No.: 10/808,145
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+3UI

i=0    RV 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0
       MV 0 0 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1

cmp result 1 0 1 1: 1 1 1 1 1 1 1 1 1 1 1 1:  static "1" identifies negative match

$\longrightarrow$ $2^0$ UI skew identified.
Insert = 1

# FIG. 9a

i=1    RV 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0
       MV 0 0 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 0 1

cmp result 1 1 0 0: 0 0 0 0 0 0 0 0 0 0 0:  static "0" identifies positive match

$\longrightarrow$ exit condition from loop

# FIG. 9b

i=2    RV 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1
       MV 0 0 0 0 1 1 1 1 0 0 0 0 1 1

cmp result 1 1 1 1: 1 1 1 1 1 1 1 1 1 1 1 1:  static "1" identifies negative match

$\longrightarrow$ positive skew identified, i.e.
skew = $2^2$ – insert = +3UI

# FIG. 9c

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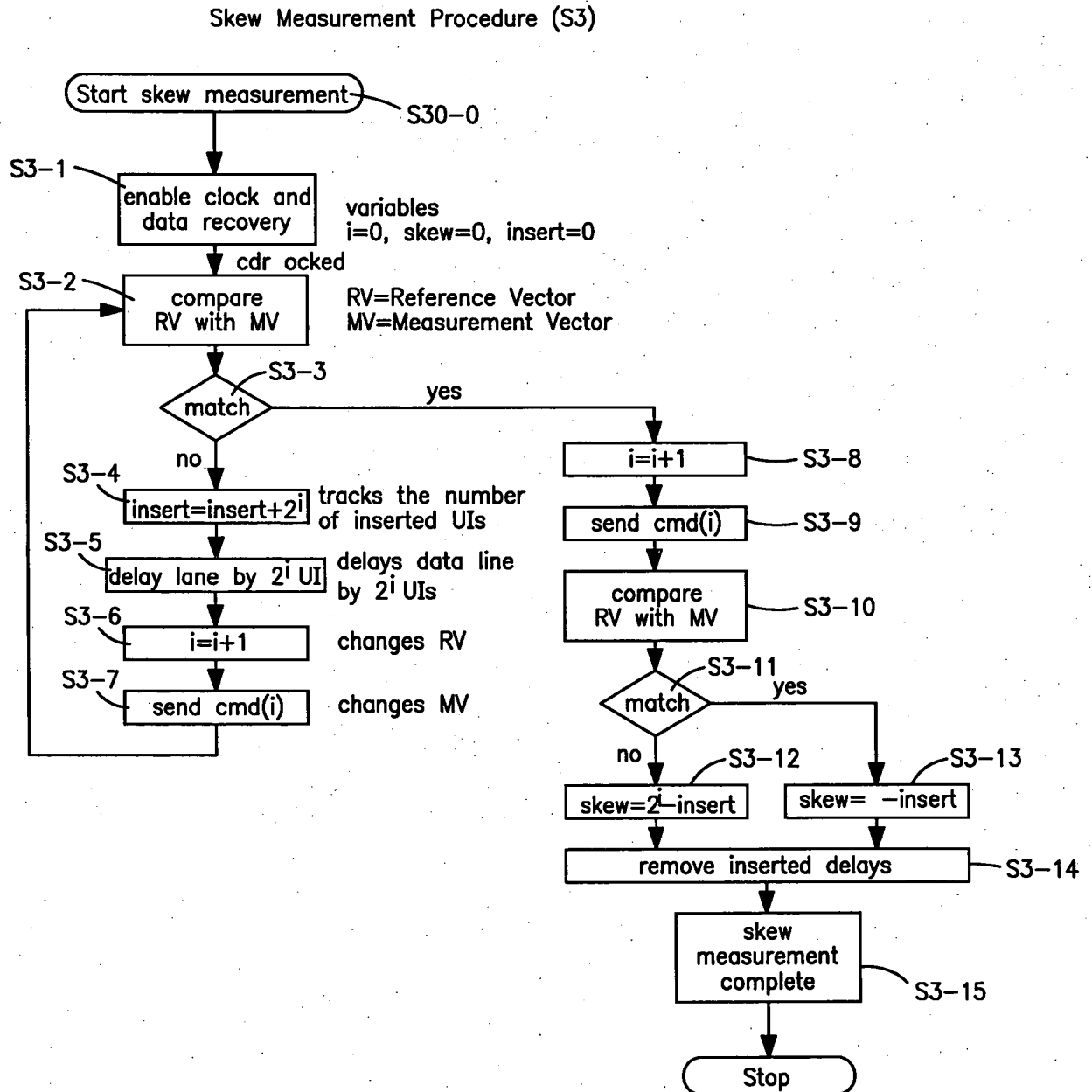Serial No.: 10/808,145
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−3UI

i=0   RV       1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0
     MV 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1

cmp result    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   static "1" identifies negative match

➡ $2^0$ UI skew identified.
Insert = 1

## FIG. 10a

i=1   RV       1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0
     MV 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1

cmp result    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   static "1" identifies negative match

➡ $2^1$ UI skew identified.
Insert = 3

## FIG. 10b

i=2   RV       1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0
     MV 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 0

cmp result    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   static "0" identifies positive match

➡ exit condition from loop

## FIG. 10c

i=3   RV       1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
     MV 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1

cmp result    0 0 0 0 0 0 0 0 0 0 0 0 0 0   static "0" identifies positive match

➡ negative skew identified, i.e.
skew = − insert = −3UI

## FIG. 10d

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Skew Compensation Procedure (Step S4)

Start — S4-0

S4-1 — identify last lane — lane with $skew_m = max(skew_n)$

S4-2 — calculate relative skew — $delay_m = max(skew_n) - skew_m$

S4-3 — delay lane by $delay_m$ UIs

S4-4 — compensation done

# FIG. 11